

**HIGH RESOLUTION 3D SEISMIC REFLECTION**  
**SURVEYS TO CHARACTERIZE AND PLAN**  
**REMEDIATION AT HAZARDOUS WASTE SITES**



**(805) 982-1005**

***NAVAL FACILITIES ENGINEERING SERVICE CENTER***

# **PROBLEM**

## **DNAPL Contamination Sites:**

- **Detection of subaqueous, free phase DNAPL is difficult.**
  - **limited to extrapolation of soil gas survey results & coincidental soil sampling**
- **Cleanup methods consist of long-term treatment of dissolved phase DNAPLs.**
  - (i.e. treating the symptom, not the problem)
  - **typically a costly and relatively ineffective effort**

## **3D SEISMIC TECHNIQUE**

- **Determine local stratigraphy:**
  - develop basic model from background research
  - interpret seismic profiles
- **Detect DNAPL:**  
**additional analysis of signal attributes:**
  - amplitude
  - frequency
  - phase

# DATA COLLECTION

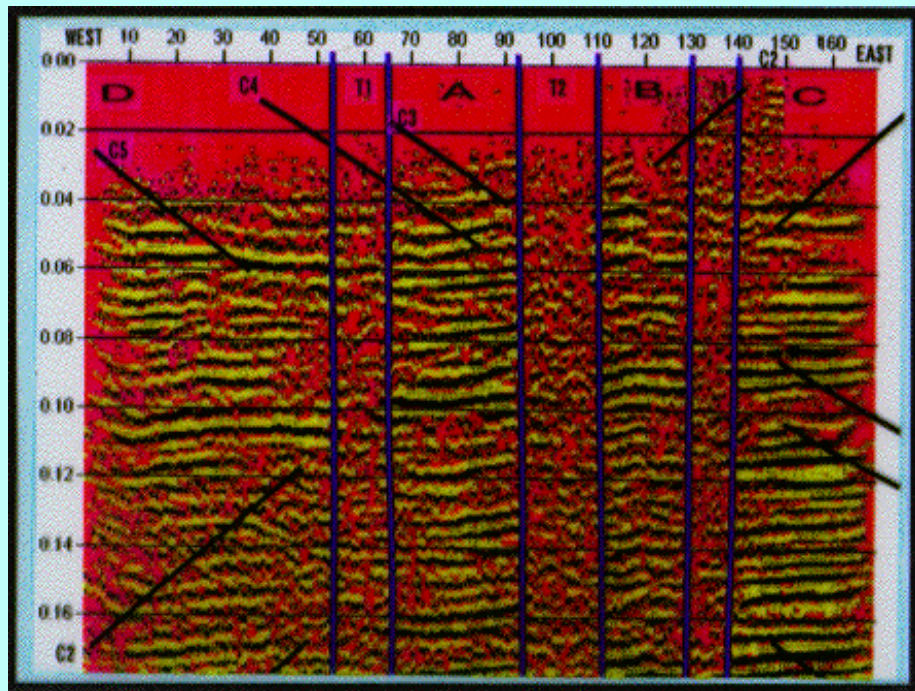


**SEISMIC SOURCE**

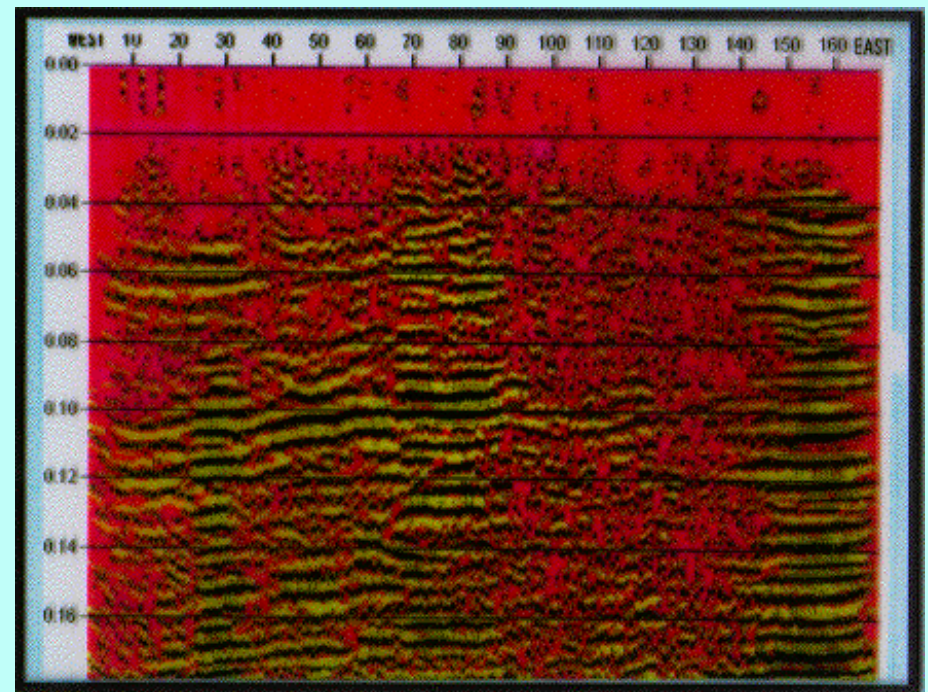


**SEISMOGRAPHS & GEOPHONES**

# SEISMIC PROFILES DISPLAYING AMPLITUDE (NAS NORTH ISLAND SITE)



**INTERPRETED FRACTURES**



**PROFILE AT CONTAMINATED AREA**

## **PROJECT DESCRIPTION:**

### **DEMONSTRATION/VALIDATION OF 3D SEISMIC SURVEYS**

- **Perform 3D seismic surveys at four DoD installations that have differing geology and DNAPL contamination.**
- **Verify these survey results by comparing to conventional site characterization methods**
- **Document the capabilities and cost effectiveness of this technology.**
- **Transfer this information to project managers responsible for site clean-ups.**

## **DEMONSTRATION SITES**

- **NAS Alameda, CA - saturated sediment**
- **Tinker AFB, OK - interbedded sand and shale**
- **Letterkenny Army Depot, PA - Karst (limestone)**
- **Allegany Ballistic Lab, WV - deformed, fractured bedrock**

## PROGRESS

- Contract delivery order awarded to Battelle/RRI in June 1996

<u>Task</u>	<u>Allegany</u>	<u>Alameda</u>	<u>Letterkenny</u>	<u>Tinker</u>
3D survey:	Mar 96*	Oct 96	Nov 96	Feb 97
Verify:	<i>May 97</i>	<i>Apr 97</i>	<i>Jun 97</i>	<i>July 97</i>
Report:	<i>Jul 97</i>	<i>Jun 97</i>	<i>Aug 97</i>	<i>Sep 97</i>

## **EXPECTED BENEFITS**

- **Install fewer wells**
- **Optimize location of wells**
- **Improve design of remediation systems**
- **Reduce chance of spreading contaminants**
- **Better define complex geology**
- **Monitor cleanup effectiveness**
- **Support intrinsic bioremediation studies**

## **USERS**

- **Personnel responsible for characterizing a site or designing a monitoring/remediation system**
  - **Remediation Project Managers (RPMs)**
  - **Cleanup contractors**

## **BARRIERS**

- **Demonstrating technical feasibility**
- **Regulatory acceptance**
- **Greater upfront costs**
- **Limits drilling revenues**

## **FUNDING SOURCE**

- **Demonstration project:**  
**ESTCP - DoD agency sponsoring demonstration & validation of innovative technologies**
- **Future work:**  
**BRAC, DERA, NAVFAC, base funds**

## **TRANSITION PLAN**

- **Identify users**
- **Develop technology transfer tools**
  - **technology data sheet**
  - **generic SOW & cost estimate**
  - **promotional video**
  - **internet home page**
  - **newsletter articles & conference papers**
- **Coordinate with various environmental agencies:**  
**EFA, EFD, ARTT; AFCEE, AL/EQW; AEC, HTRW-CX;**  
**EPA/DoD/DOE Roundtable; ITRC Work Group; CMECC,**  
**NERL (EMSL)**

# **JOINTNESS**

**Demonstrations being performed at Navy, Air Force, and Army facilities:**

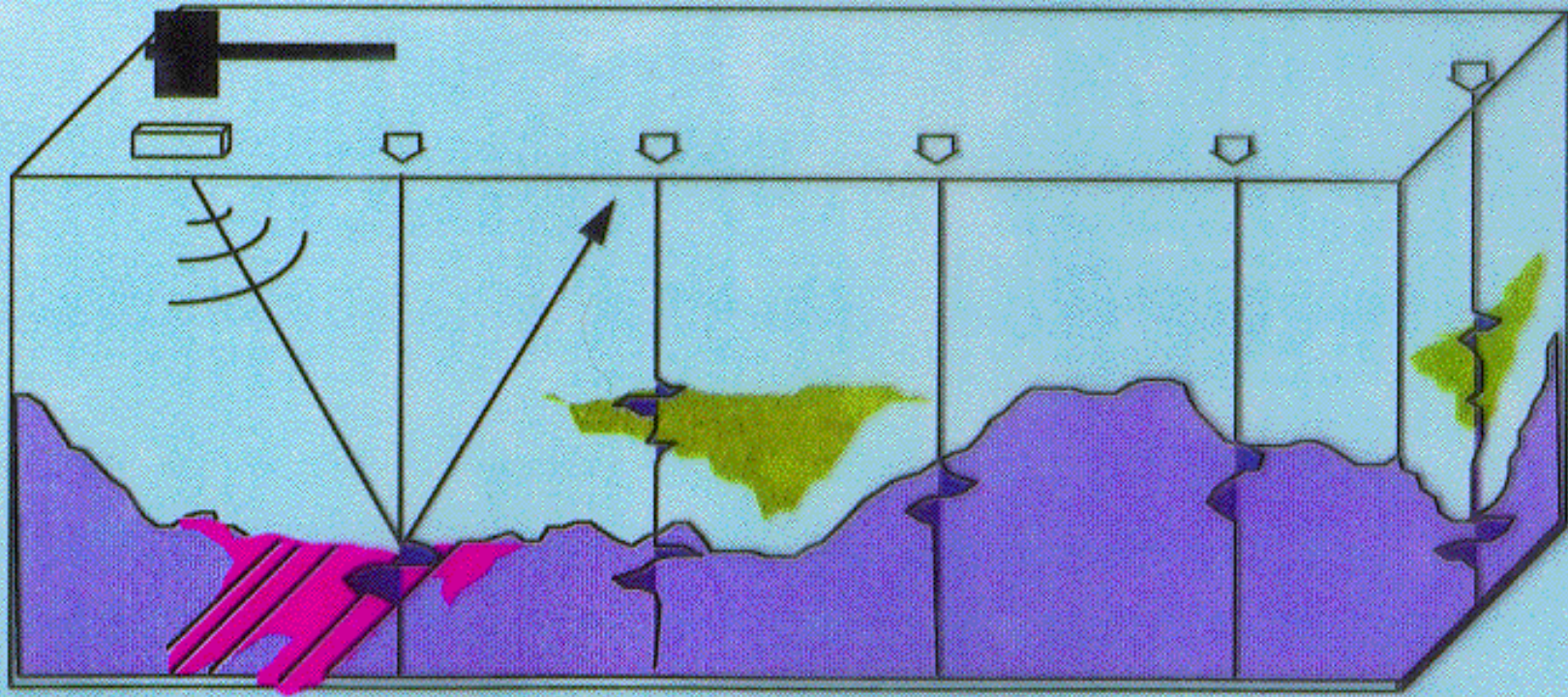
- **Naval Air Station Alameda, CA**
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## **ISSUES**

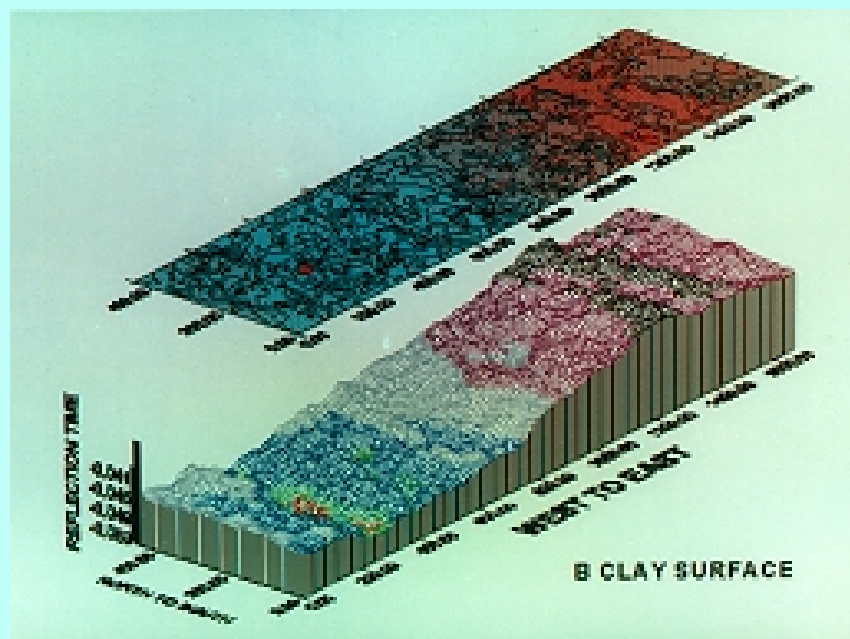
- **Finding DNAPL free-product at the sites**
- **Demonstrating the capability of this technique to directly detect DNAPLs**

## BASIC PRINCIPLE

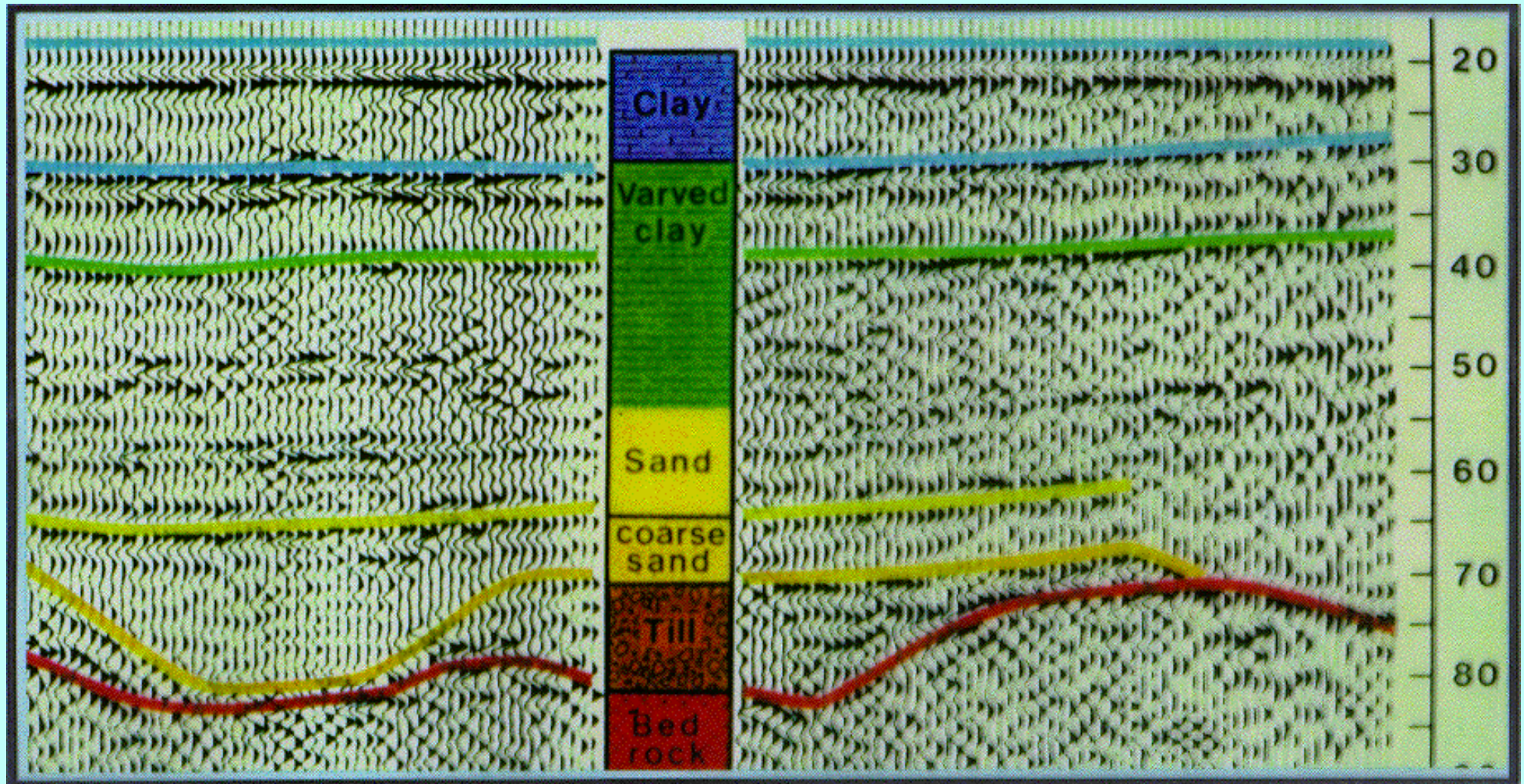
- SOUND IS REFLECTED OFF EARTH LAYERS
- REFLECTIONS ARE DIGITIZED
- DIGITIZED SIGNALS ARE PROCESSED
- TRUE 3D IMAGE IS CREATED



## 3D DATA DISPLAY: STRATIGRAPHIC LAYER



# INTERPRETED SEISMIC SECTION WITH BORING LOG



**3D ELECTRO-MAGNETIC RESISTIVITY**  
**SURVEYS FOR HIGH RESOLUTION**  
**IMAGING OF SUBSURFACE CONTAMINATION**



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# **PROBLEM**

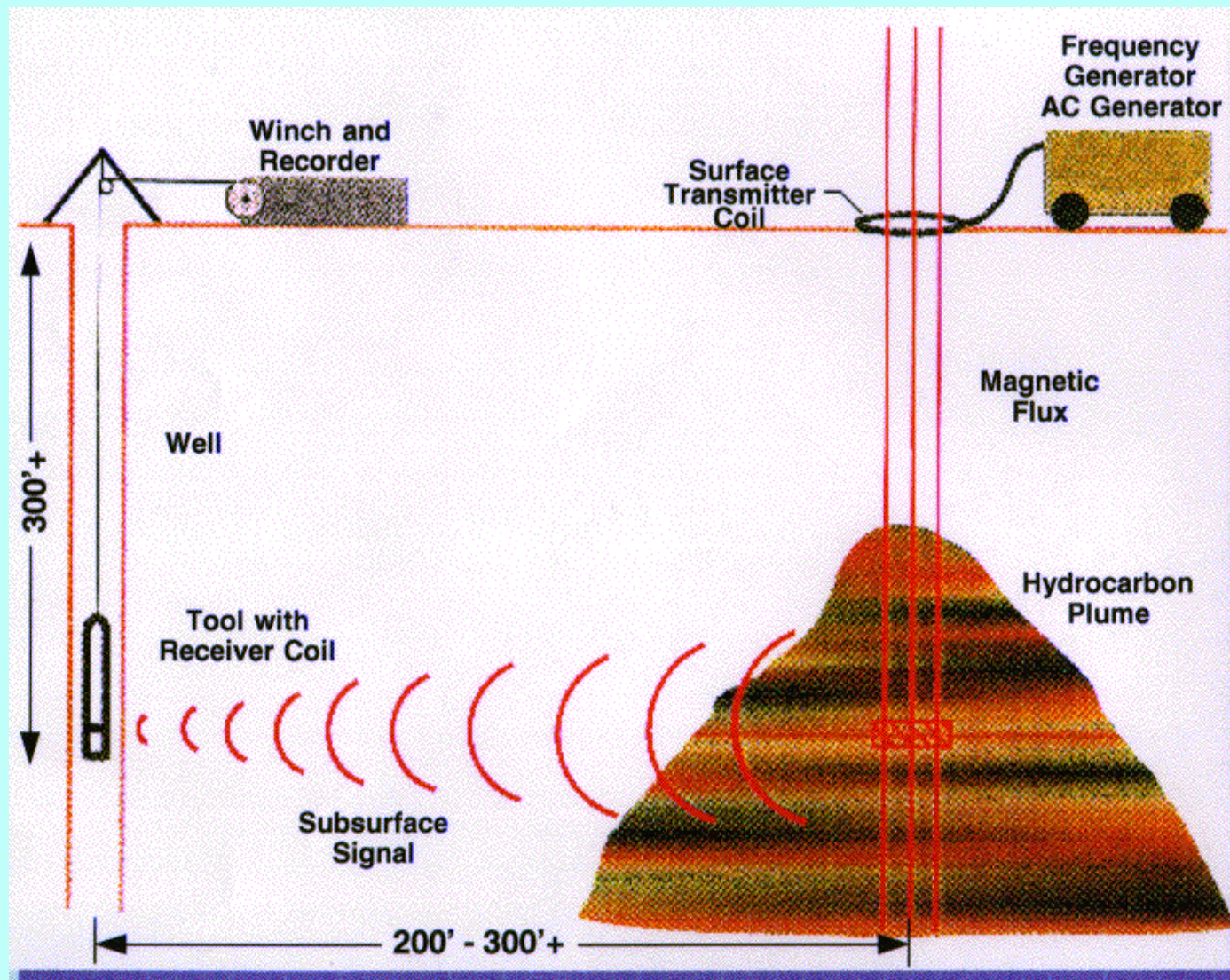
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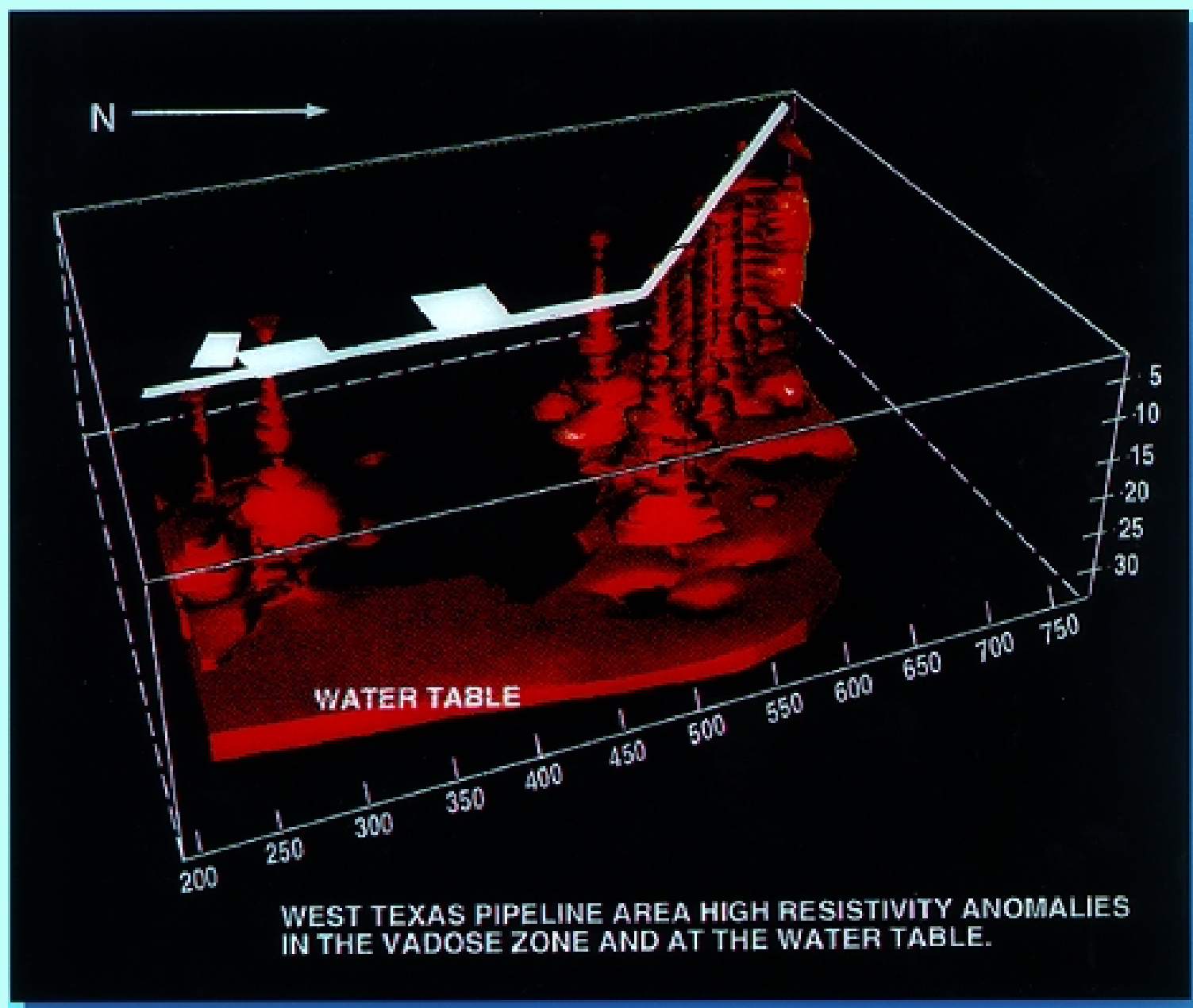
## **3D ELECTROMAGNETIC TECHNIQUE**

- **Determine local stratigraphy:**
  - **Develop basic model from background research**
  - **Interpret zones of varying resistivity**
- **Detect DNAPL:**
  - **Identify high-resistivity anomalies which represent the presence of contamination**

# DATA COLLECTION



## DATA DISPLAY



# **PROJECT DESCRIPTION**

## **DEMONSTRATION/VALIDATION OF 3D EM SURVEYS**

- **Perform 3D EM surveys at four DoD installations that have differing geology and DNAPL contamination.**
- **Verify these survey results by comparing to conventional site characterization methods**
- **Document the capabilities and cost effectiveness of this technology.**
- **Transfer this information to project managers responsible for site clean-ups.**

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## **PROGRESS**

- **Contract to be awarded in *April 1997***

<b><u>Task</u></b>	<b><u>Alameda</u></b>	<b><u>Tinker</u></b>	<b><u>Letterkenny</u></b>	<b><u>Allegany</u></b>
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## **EXPECTED BENEFITS**

- **Install fewer wells**
- **Optimize location of wells**
- **Improve design of remediation systems**
- **Reduce chance of spreading contaminants**
- **Estimate volume of DNAPL/LNAPL contamination**
- **Better define complex geology**
- **Monitor cleanup effectiveness**
- **Support intrinsic bioremediation studies**

## **USERS**

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# **ISSUES**

- **Finding DNAPL free-product at the sites**

# **EOL SYSTEM DESCRIPTION**

## **Transmitter Loop**

**4 meter<sup>2</sup> area**

**32 turns**

**11 amps**

## **Receiver**

**2.5' length**

**1.6" diameter**

**30,000 turn,  
28 gage wire**

## **Data**

**16 byte A/D  
converter**

**1/100 scale  
resolution**

**263 Hz**

## RESISTIVITY VALUES

<u>saturated soil</u>	<u>ohm-m</u>	<u>saturated rock</u>	<u>ohm-m</u>
• clay/mud	2-5	shale	1-10
• silt	5-20	sandstone	10-50
• sand	10-50	limestone	50-10 <sup>4</sup>
• gravel	20-50	volcanic rock	100-500
•		metamorphic rock	300-10 <sup>3</sup>
<u>vadose zone soils:</u>	<u>10-50 times resistivity</u>		

minimum resistivity contrast = 1.5

<u>contaminants</u>	<u>ohm-m</u>
• <u>non-dissolved DNAPL</u>	>10 <sup>6</sup>
• <u>non-dissolved LNAPL</u>	>10 <sup>6</sup>